Collider Physics: Theoretical Efforts at BNL

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Outline

- Introduction to Supersymmetry
- From Theory to Experiment
- Dark Matter Constraints in mSUGRA
- Predictions for the Tevatron, LHC and Linear Collider
- Conclusions

The MSSM

Gauge symmetry is the same as in the SM: $SU(3)_C \times SU(2)_L \times U(1)_Y$.

Particle content of the MSSM:

$$\begin{pmatrix} \hat{u} \\ \hat{d} \end{pmatrix}_L,\ \hat{U}^c,\ \hat{D}^c\ ;\quad \begin{pmatrix} \hat{\nu}_e \\ \hat{e} \end{pmatrix}_L,\ \hat{E}^c,$$
$$\begin{pmatrix} \hat{c} \\ \hat{s} \end{pmatrix}_L,\ \hat{C}^c,\ \hat{S}^c\ ;\quad \begin{pmatrix} \hat{\nu}_\mu \\ \hat{\mu} \end{pmatrix}_L,\ \hat{M}^c,$$
$$\begin{pmatrix} \hat{t} \\ \hat{b} \end{pmatrix}_L,\ \hat{T}^c,\ \hat{B}^c\ ;\quad \begin{pmatrix} \hat{\nu}_\tau \\ \hat{\tau} \end{pmatrix}_L,\ \hat{T}^c,$$
$$\begin{pmatrix} \hat{h}_u^+ \\ \hat{h}_u^0 \end{pmatrix},\quad \begin{pmatrix} \hat{h}_d^- \\ \hat{h}_d^0 \end{pmatrix}.$$

Gauge sector physical particles:

$$g, W^\pm, Z^0, \gamma.$$

Gaugino and higgsino fields form the following physical particles:

$$\tilde{g}, \tilde{W}_i^\pm, \tilde{Z}_j^0, \qquad i = 1, 2, \quad j = 1, 2, 3, 4.$$

General MSSM has 124 parameters! That leads us to consider more restricted theories, such as

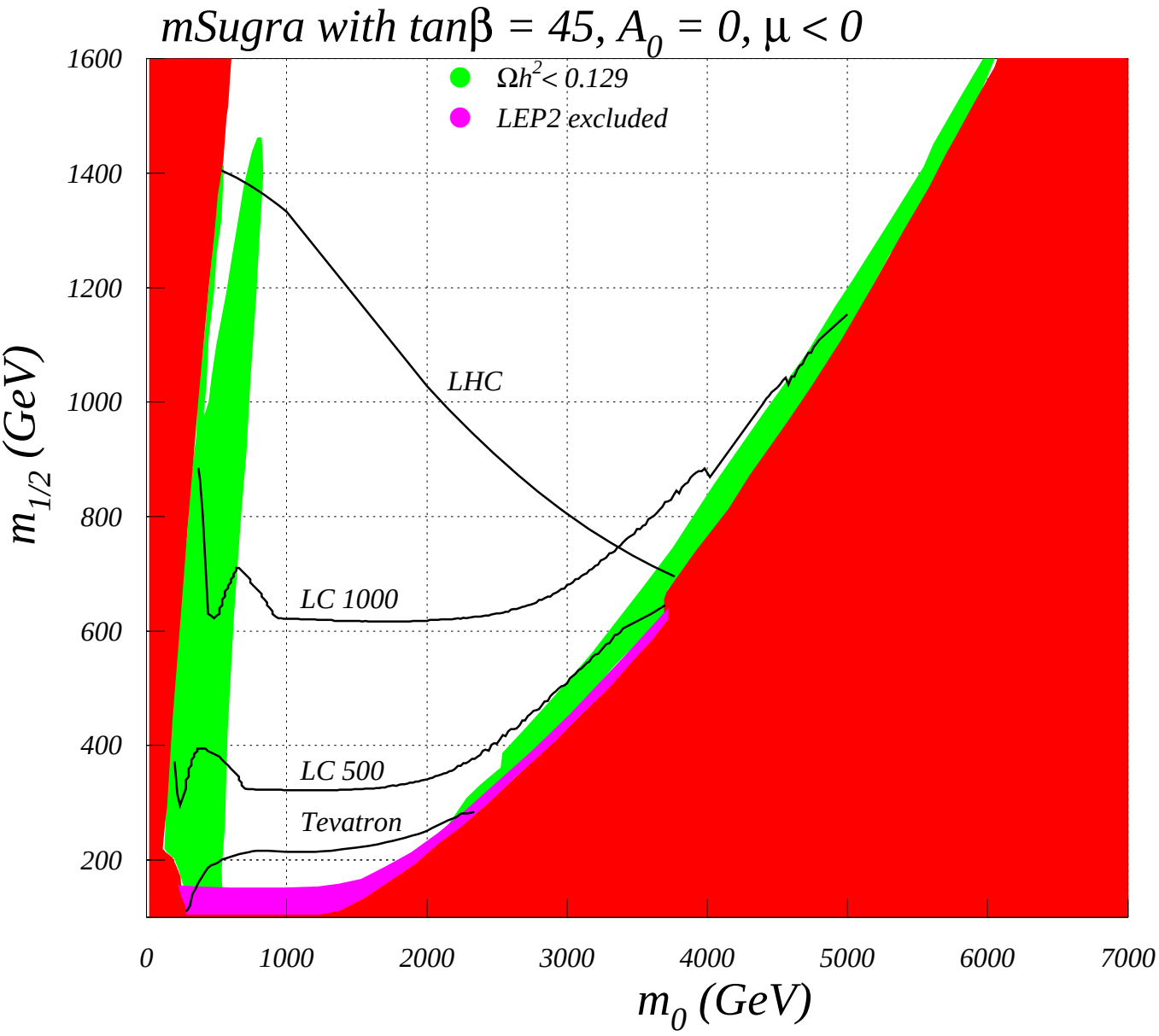
mSUGRA (CMSSM)

- Supersymmetry is broken in the hidden sector, giving rise to a massive gravitino
- SUSY breaking in the hidden sector generates soft SUSY breaking terms in the visible sector
- Model has 5 parameters:
m_0, $m_{1/2}$, A_0, $\tan\beta \equiv \frac{v_u}{v_d}$, $sgn(\mu)$
- The lightest neutralino $\tilde{Z}_1^0$ is an LSP and a good candidate for CDM particle

From Theory to Experiment

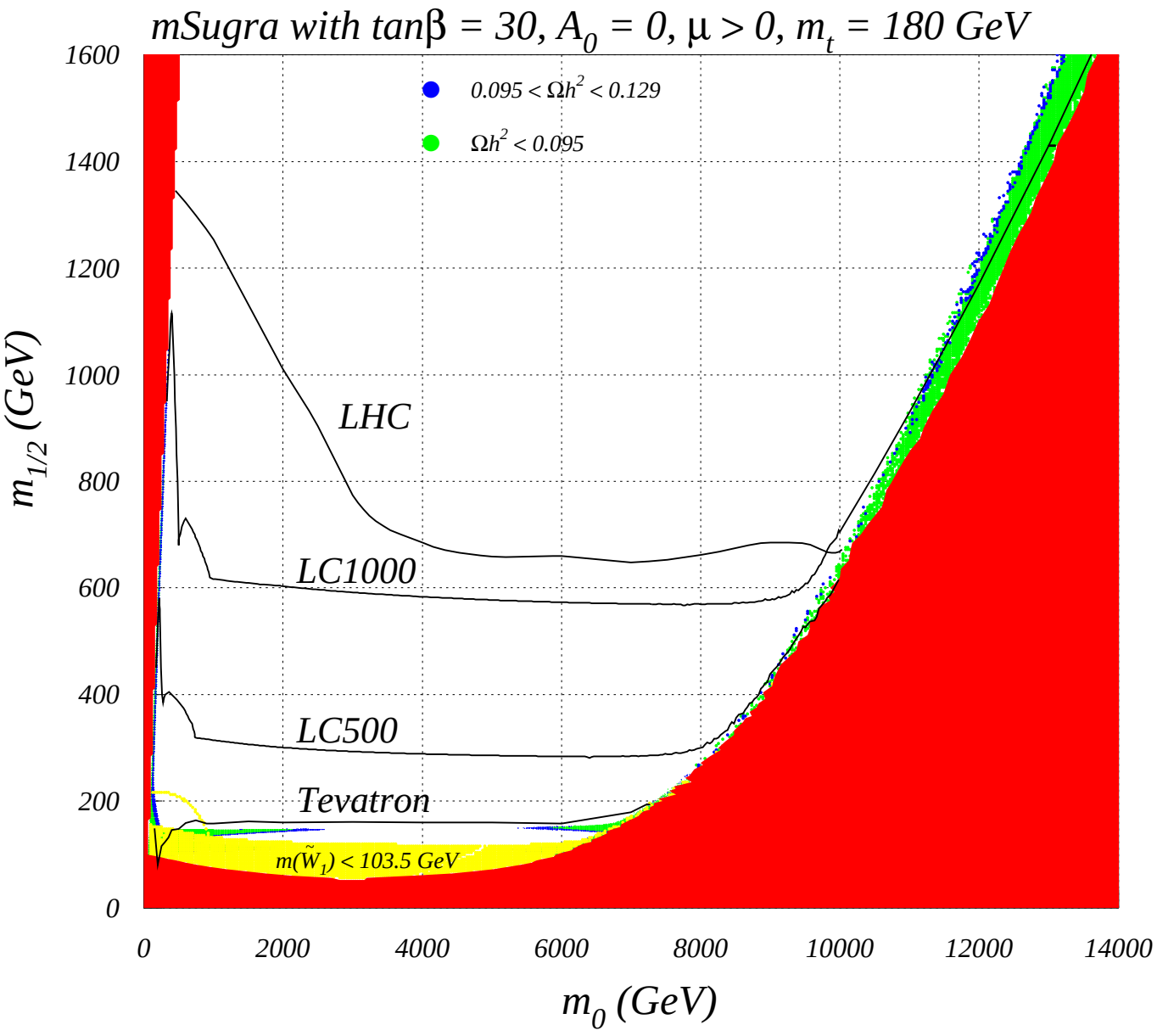
Input parameters at GUT scale $\Rightarrow$ Have to run RGEs to the electroweak scale
One needs a mass spectrum calculator:
ISASUGRA, ISASUSY (H. Baer, F. Paige, S. Protopopescu and X. Tata), ...

Lagrangian $\Rightarrow$ Cross sections
Not enough, need an event generator: convolute with PDFs, include initial and final state radiation, hadronize, etc.
We use ISAJET (H. Baer, F. Paige, S. Protopopescu and X. Tata)



Tevatron, LHC and LC reaches in mSUGRA. Red region is excluded because $\tilde{\tau}_1$ is the LSP (left) or no rEWSB occurs (right). Magenta region is ruled out by LEP2.

H. Baer, A. Belyaev, T. K. and X. Tata, JHEP 0402:007,2004



Tevatron, LHC and LC reaches in mSUGRA. Red region is excluded because $\tilde{\tau}_1$ is the LSP (left) or no rEWSB occurs (right). Yellow region is ruled out by LEP2.

H. Baer, T. K. and X. Tata, JHEP 0406:061,2004

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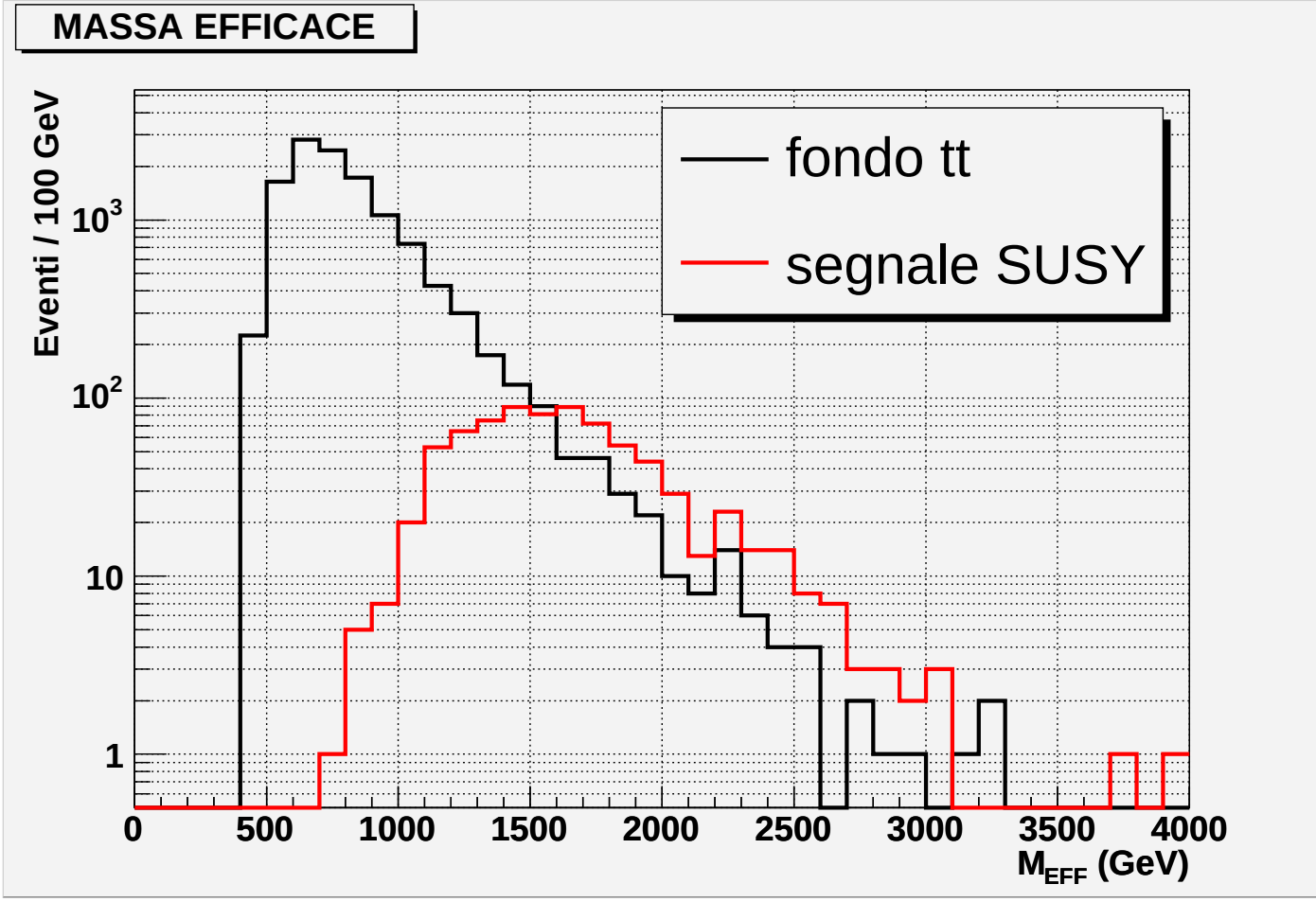

Effective mass ($M_{eff} = E_T^{miss} + \Sigma p_T^{jets}$) distribution in gluino pair production events with lepton veto, large E_T^{miss} and at least 5 hard jets.

U. De Sanctis, T. Lari and C. Troncon, 'Update on Focus Point Studies'

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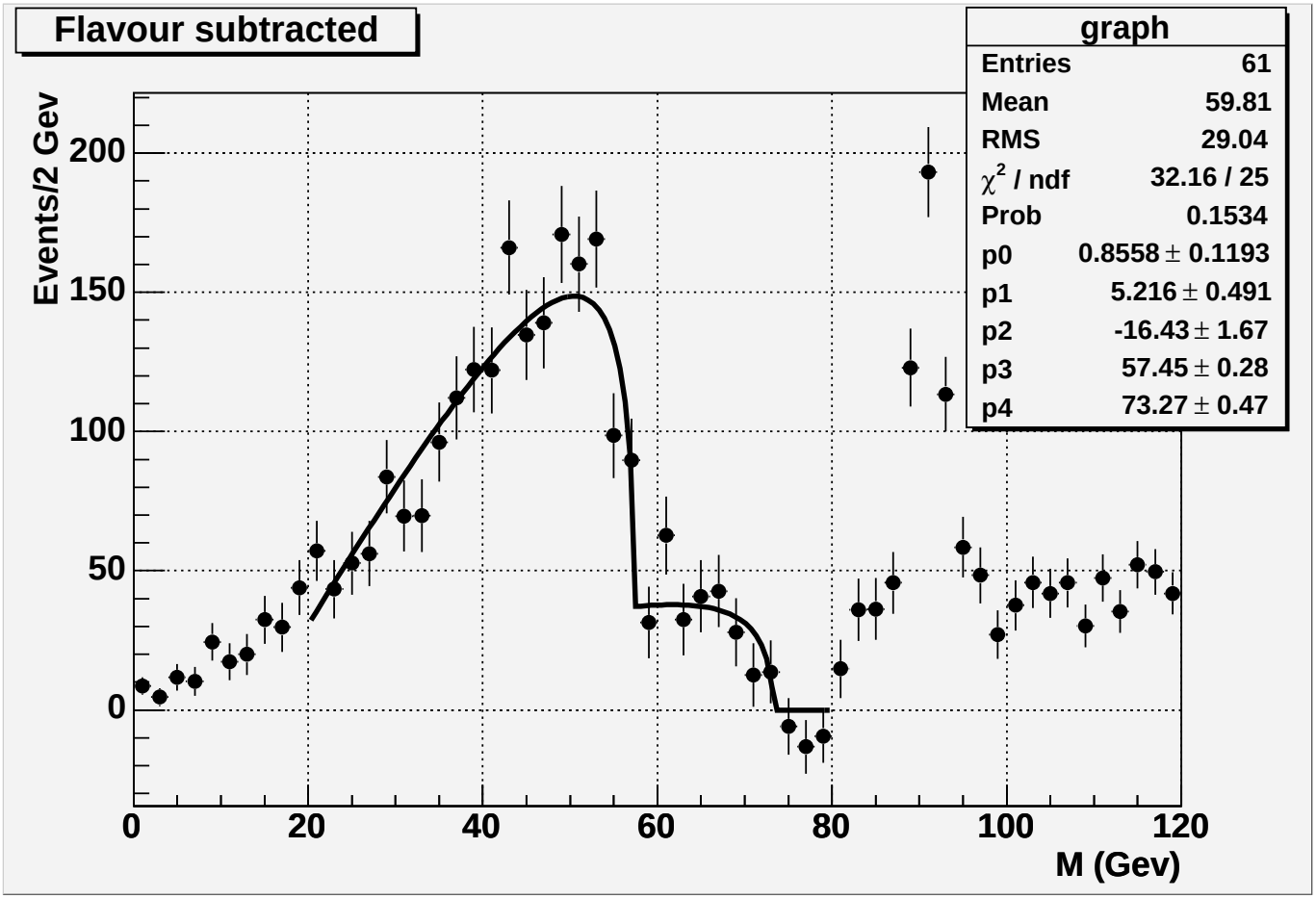

Dilepton invariant mass distribution from gluino pair production.

$m(\tilde{\chi}_3^0) - m(\tilde{\chi}_1^0) = 73.27 \pm 0.47$ GeV,

$m(\tilde{\chi}_2^0) - m(\tilde{\chi}_1^0) = 57.45 \pm 0.28$ GeV.

U. De Sanctis, T. Lari and C. Troncon, 'Update on Focus Point Studies'

Conclusions

- Dark matter constraints determined the direction of theoretical collider research

- Prospects of current and future collider experiments in the framework of mSUGRA were evaluated, focusing on DM-favored parameter regions

- Accumulated knowledge is used by the experimental groups to do full simulations and prepare for the turn-on of the LHC